Remarks

This Reply is timely filed and is responsive to the Office Action mailed August 9, 2005 (the "Office Action"). In the Office Action, claims 88-102 were rejected and claim 103 was withdrawn by the Examiner as being directed to a non-elected invention.

In this Reply, no claims have been amended. The specification has been amended to remove a typographical error that resulted in the omission of "of". Claim 103 has been withdrawn pursuant to a constructive restriction. No new matter has been added.

Now turning to claim rejections based on cited art, Claims 88, 90-91, 94-99, and 100-102 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,348,278 to La Pierre et al. ("La Pierre") in view of U.S. Patent No. 5,449,568 to Micheli et al. ("Micheli"). Claim 89 is rejected under 35 U.S.C. § 103(a) as being unpatentable over La Pierre in view of Micheli, as applied to claim 88, and further in view of U.S. Patent No. 6,375,716 to Burchell et al. ("Burchell"). Claims 92 and 93 are rejected under 35 U.S.C. § 103(a) as being unpatentable over La Pierre in view of Micheli, as applied to claim 88, and further in view of U.S. Patent No. 4,810,472 to Andrew et al. ("Andrew").

Regarding independent claim 88, according to the Examiner:

1. Claims 88, 90-91, 94-99, and 100-102 are rejected under 35 U.S.C. 103(a) as being unpatentable over La Pierre et al. (6,348,278) in view of Micheli et al. (5,449,568). Note, the system is being examined as an apparatus. Regarding claims 88, 94-95, 97, and 101, La Pierre discloses a system for converting fuel energy to electricity (Fig. 2), comprising: a reformer (12) for converting a higher molecular weight gas (hydrocarbon, Col. 7, lines 14-18 and methane gas, Col. 7, line 36) into at least one mixed gas stream of lower average molecular weight (Col. 8, lines 46-51) comprising at least a first lower molecular weight gas (H2) and a second gas (CO) said first and second gases being different gases; a separator (14) for dividing said mixed gas stream into a first gas stream mainly comprising said first lower molecular weight gas (via line 40) and a second gas stream mainly comprising said second gas (CO); the first gas (purified hydrogen via line 40) is fed to the fuel cell 52 to produce electricity (64); and the retentate stream is fed to the turbines (45,47). La Pierre fails to disclose a second fuel cell for electrochemically oxidizing said second gas stream to produce electricity. It appears La Pierre discloses at least one turbine to produce electricity from expansion of said mixed gas (Figure2, (45) and (47). Micheli '568 teaches the second gas stream separated from the CO2 separator (44) is fed to the fuel cell (14) to produce electricity (39) and at least one turbine (64, 68) from expansion of said mixed gas to produce electricity (66,70). Thus, it would have been obvious in view of Micheli '568 to one having ordinary skill in the art to modify the fuel converting system of La Pierre with a second fuel cell and at least one turbine as taught by Micheli '568 to produce electricity.

Applicants respectfully disagree with certain assertions above required to support the claim rejections. However, before reviewing the Examiner's assertion regarding the cited art, Applicants will first review the claimed invention as recited in claim 88. Claim 88 recites a system for converting fuel energy to electricity, comprising a reformer for converting a higher molecular weight gas into at least one mixed gas stream (fuel stream) of lower average molecular

weight comprising at least a first lower molecular weight gas and a second gas, the first and second gases being different gases. At least one turbine produces electricity from expansion of the mixed gas stream (fuel stream provided by the reformer).

A separator is provided for then dividing the mixed gas stream into a first gas stream mainly comprising the first lower molecular weight gas and a second gas stream mainly comprising the second gas. The claimed system also recites two (2) fuel cells which each produce electricity from the respective gas streams. A first fuel cell is for electrochemically oxidizing the first gas stream and a second fuel cell is provided for electrochemically oxidizing the second gas stream.

In the preferred embodiment, the fuel energy is provided by natural gas/methane, where the reformate is a mixture of gases, primarily hydrogen and carbon monoxide which after separation into two gas streams, one comprising primarily hydrogen and one comprising primarily carbon monoxide, are electrochemically oxidized by separate fuel cells with the concomitant production of electricity and heat. As noted in Applicants' specification on page 10 lines 1-5, the claimed invention provides high efficiency power output from fuels, such as natural gas, by about 20 to 30 % over existing power systems to approximately 80 to 85%.

A principal difference in the claimed invention over the cited art that provides a significant increase in efficiency is that in the claimed inventive system the mixed gas stream (fuel stream) first goes to an expansion turbine for generation of electricity before being electrochemically oxidized. As noted on pages 12 lines 2 -7 Applicants' application:

> The thermodynamic efficiency of the turbine expansion process is increased compared to prior systems in at least two ways. The use of a working fluid or working fluid mixture having a high specific volume (such as CO and H_2) to power turbine 120 results in an increased power density and energy conversion efficiency for the overall power system compared to systems which use lower specific volume working fluids, such as conventional combustion products (e.g. CO_2 and air).

As noted on page 12, line 18 to page 13, line 1:

Thus, assuming the same rate of expansion in turbine 120, the specific power (power/mass) generated by the expansion of the synthesis gas is approximately two and three times greater, respectively, compared to turbines which use steam or air as the working fluid.

The second "way" the claimed arrangement where the turbine produces electricity from expansion of the mixed gas stream increases efficiency is described on page 13, lines 3-8 (copied below):

In addition, the use synthesis gas as the working fluid for turbine expansion largely avoids the inherent thermodynamic efficiency limitations imposed by the Carnot principle on conventional power systems which use cyclic processes because the synthesis gas used by system 100 goes to the turbine 120 at an elevated pressure (e.g. the pressure of a typical gas main) and is subsequently reacted electrochemically.

The same mixed gas stream (fuel stream) is then directed to a gas separation device and the resulting respective separated gas streams, are directed to separate fuel cells for electrochemical oxidation and production of additional electricity. In contrast, as will be demonstrated below, La Pierre and Micheli both exclusively teach first directing the fuel gases to a fuel cell for generation of electricity. The fuel gases thus undergo electrochemical reactions and are as a result changed in composition.

La Pierre is entitled "method and system for supplying hydrogen for use in fuel cells" and discloses a method and system for efficiently producing hydrogen that can be supplied to a fuel cell. The method and system produce hydrogen in a reforming reactor using a hydrocarbon stream and water vapor stream as reactants. The hydrogen produced in the reformate stream is purified in a hydrogen separating membrane to form a retentate stream stripped of H_2 and a purified hydrogen stream. The purified hydrogen is then fed to a fuel cell where electrical energy is produced and a fuel cell exhaust stream containing water vapor and oxygen depleted air is emitted. In one embodiment, a means and method is provided for recycling a portion of the

retentate stream to the reforming reactor for increased hydrogen yields. In another embodiment, a combustor is provided for combusting a second portion of the retentate stream to provide heat to the reforming reaction or other reactants. In the preferred embodiment, the combustion is carried out in the presence of at least a portion of the oxygen depleted air stream from the fuel cell.

The Examiner asserts that "It appears that La Pierre discloses at least one turbine to produce electricity from expansion of said mixed gas (Figure 2, (45) and (47)." Applicants respectfully disagree with this assertion in two (2) respects. Applicants first respectfully point out that the "mixed gas stream" utilized by Applicants' claimed turbine is the output gas stream provided by the claimed reformer (without separation; "produce electricity from expansion of said mixed gas stream"). Although La Pierre discloses turbines 45 and 47, La Pierre does not disclose or suggest using these turbines to produce electricity, nor do turbines 45 and 47 utilize the claimed mixed gas stream output by a reformer. Instead, as clearly indicated in Fig. 2 and the associated La Pierre disclosure, turbines 45 and 47 utilize retentate recycle stream 46 and exhaust tail gas stream 48, respectively, which are derived from retentate stream 42. The reformate 32 output by reformer 12 is supplied to hydrogen separation membrane 14 which separates reformate 32 into substantially pure hydrogen 40 which is fed to fuel cell 52 and retentate stream 42 which after division by splitter 44 is supplied to turbines 45 and 47. Retentate stream 42 portions are, respectively, taught for increasing (Column 14; Lines 31-32) and decreasing (Column 14; Lines 35-36) the gas stream pressures. Col. 14, lines 27-49 are copied below for convenient reference:

> The retentate stream 42 exiting the retentate side 36 of the hydrogen separating membrane 14 is divided into a retentate recycle stream 46 and exhaust tail gas stream 48. The retentate recycle stream 46 is preferably passed through, for example, *a recycle turbine 45 or other pressure increasing device to increase the pressure of the retentate recycle stream 46 to*

the operating pressure of the reforming reactor. The exhaust tail gas stream 48 is preferably passed through an exhaust turbine 47 or other similar pressure reducing device to decrease the pressure of the exhaust tail gas stream 48 to the operating pressure of the combustor. The exhaust tail gas stream 48 is also preferably passed through a heat exchanger 49 and exhaust tail gas process water condenser 51 for cooling the exhaust tail gas stream 48 and separating water in the exhaust tail gas stream 48 from the other gaseous components. The tail gas process water condenser 51 also preferably includes a condensate collection device (not shown), such as a "knock out pot," for collecting the condensate. The cooled, depressurized, and substantially water free exhaust tail gas stream 53 is fed into the internal combustor 110 where it is combusted as previously described. The exhaust tail gas process water 55 from condenser 51 may be recycled to the reforming reactor 12.

Thus, La Pierre does not disclose or suggest Applicants' claimed turbine for producing electricity from expansion of the mixed gas output. Moreover, as noted in Applicants' previously filed Reply, La Pierre does not disclose or suggest a second fuel cell to electrochemically oxidize a second gas stream (the retentate stream) to produce electricity. Instead, the retentate stream is used for increasing (Column 14; Lines 31-32) and decreasing (Column 14; Lines 35-36) the gas stream pressures.

Micheli is used by the Examiner in an attempt to make up for La Pierre's acknowledged single fuel cell deficiency and in an attempt to identify a turbine to produce electricity. According to the Examiner regarding Micheli:

> said mixed gas (Figure2, (45) and (47). Micheli '568 teaches the second gas stream separated from the CO2 separator (44) is fed to the fuel cell (14) to produce electricity (39) and at least one turbine (64, 68) from expansion of said mixed gas to produce electricity (66,70). Thus, it would have been obvious in view of Micheli '568 to one having ordinary skill in the art to modify the fuel converting system of La Pierre with a second fuel cell and at least one turbine as taught by Micheli '568 to produce electricity.

Applicants respectfully disagree with many of the assertions above regarding Micheli and will demonstrate below that (i) it is not reasonable to combine La Pierre and Micheli and that

even assuming *arguendo* that La Pierre and Micheli are reasonable to combine, (ii) Micheli does not make up for La Pierre's deficiencies relative to Applicants' claimed invention.

Micheli discloses an indirect-heated gas turbine cycle is bottomed with a fuel cell cycle with the heated air discharged from the gas turbine being directly utilized at the cathode of the fuel cell for the electricity-producing electrochemical reaction occurring within the fuel cell. The hot cathode recycle gases provide a substantial portion of the heat required for the indirect heating of the compressed air used in the gas turbine cycle. A separate combustor provides the balance of the heat needed for the indirect heating of the compressed air used in the gas turbine cycle. Hot gases from the fuel cell are used in the combustor to reduce both the fuel requirements of the combustor and the NOx emissions therefrom. Residual heat remaining in the air-heating gases after completing the heating thereof is used in a steam turbine cycle or in an absorption refrigeration cycle. Some of the hot gases from the cathode can be diverted from the air-heating function and used in the absorption refrigeration cycle or in the steam cycle for steam generating purposes.

Micheli discloses a system having a single fuel cell as does La Pierre. Micheli's fuel cell 14 receives fuel, such as natural gas 37 at anode 36. Micheli does not disclose or suggest a reformer nor obviously a separator for dividing the reformate. Although the Examiner asserts it would have been "obvious in view of Micheli '568 to one having ordinary skill in the art to modify the fuel converting system of La Pierre with a second fuel cell ... as taught by Micheli to produce electricity, the Examiner does not describe how such a hypothetical combination would be accomplished. Applicants believe that Micheli's single fuel cell 14 in La Pierre's system could only be possibly realized by placing fuel cell 14 in the retentate stream 42 path. However, neither La Pierre or Micheli disclose or suggest electrochemically oxidizing a second gas stream

(the retentate stream) to produce electricity. Moreover, this proposed insertion would effectively nullify La Pierre's desired action of turbines 45 and 47 for increasing (Column 14; Lines 31-32) and decreasing (Column 14; Lines 35-36) the gas stream pressures. In addition, the disclosed composition of retentate stream 42 by La Pierre comprises water vapor, carbon dioxide, methane and carbon monoxide (Column 8; Lines 48-50) clearly teaches away from use as a fuel as only carbon monoxide is directly electrochemically oxidizable.

Micheli's turbine 64 is a steam turbine in which a boiler is used to produce steam to drive the turbine to produce electricity. Since la Pierre does not provide a steam source, Micheli's turbine is not reasonably combinable with la Pierre's system. In light of the above described obstacles to adding Micheli's single fuel cell and electricity producing turbine to La Pierre's system, Applicants submit that it is not reasonable to combine La Pierre and Micheli.

Micheli does not make up for La Pierre's deficiencies regarding Applicants' claimed "second fuel cell for *electrochemically oxidizing* said second gas stream to produce electricity". The Examiner asserts that "Micheli '568 teaches the second gas stream separated from the CO_2 separator (44) is fed to the fuel cell (14) to produce electricity (39) and at least one turbine (64, 68) from expansion of said mixed gas to produce electricity (66, 70)". However, Micheli clearly teaches (Col. 6; Lines 39-42) that the CO_2 separated from the reactor exhaust stream is mixed with the cathode air stream of the single fuel cell 14 in Micheli's invention. Although the retentive gas does contribute to the production of electricity by fuel cell 14, these exhaust stream gases are directed to the cathode of fuel cell 14 where they are *electrochemically reduced*, not *electrochemically oxidized* (at the anode) as claimed by Applicants("a second fuel cell for *electrochemically oxidizing* said second gas stream to produce electricity").

Micheli also does not make up for La Pierre's deficiencies regarding Applicants' claimed "at least one turbine to produce electricity from expansion of said mixed gas stream". Micheli does not disclose or suggest directing a mixed gas stream (the reformate) to a turbine to produce electricity. As noted above, Micheli's turbine 64 is a steam turbine in which a boiler 62 is used to produce steam to drive the turbine to produce electricity.

Micheli's turbine 68 also does not involve the expansion of a mixed gas stream to produce electricity. Rather, Micheli teaches(Col. 8, lines 8-12) the use of "...a low-pressure turbine 68 with an electrical generator 70 is connected by conduit 72 to the cathode discharge line 48 for receiving a portion or all of the cathode exhaust stream." Although Micheli's turbines 64 and 68 do provide electricity, both provide electricity derived from gaseous products output by the fuel cell which have undergone electrochemical reaction, not Applicants claimed turbine which "produce[s] electricity from expansion of said mixed gas stream" (reformate; which has not undergone electrochemical reaction).

Thus, Micheli does not make up for La Pierre's deficiency of failing to disclose or suggest Applicants' claimed (i) " turbine to produce electricity from expansion of said mixed gas stream" and ii) "a second fuel cell for *electrochemically oxidizing* said second gas stream to produce electricity". Accordingly, since as demonstrated above it is not reasonable to combine La Pierre and Micheli and that even assuming *arguendo* that La Pierre and Micheli are reasonable to combine, Micheli does not make up for La Pierre's deficiencies relative to Applicants' claimed invention. Accordingly, Applicants submit that claim 88 and its respective dependent claims are patentable over the cited art.

Applicants have made every effort to present claims which distinguish over the cited art, and it is believed that all claims are now in condition for allowance. However, the Examiner is

invited to call the undersigned (at 561-671-3662) if it is believed that a telephonic interview would expedite the prosecution of the application to an allowance. The Commissioner for Patents is hereby authorized to charge any deficiency in fees due with the filing of this document and during prosecution of this application to Deposit Account No. 50-0951.

Respectfully submitted,

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